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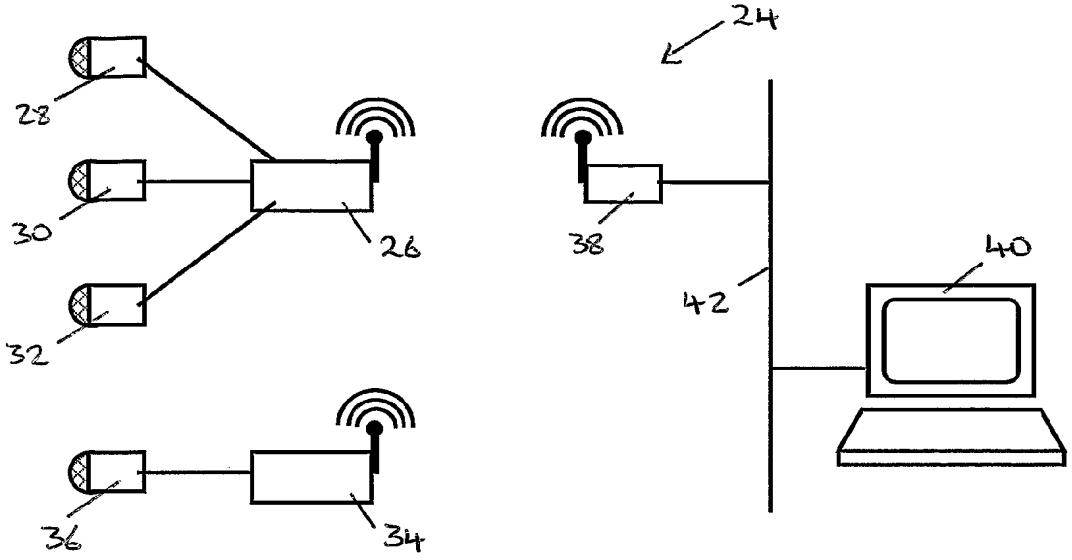

(57) Abstract: A system and method for the configuration of remote sensors in a wireless sensor monitoring system is described. The system includes one or more transmission modules, a data receiving unit and one or more sensors, each sensor being coupled to a transmission module. The transmission module stores configuration data relating to the sensors to which it is connected. In the use of the system, data from the sensors and configuration data relating to sensors is sent from a transmission module to the data receiving unit via a wireless link. The data receiving unit is able to interpret data received from the sensors on the basis of the configuration data stored at the transmission module.

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Wireless Sensor Monitoring Systems

This invention relates to wireless sensor monitoring systems. In particular, this invention relates to the configuration of remote sensors in a wireless sensor monitoring system.

Figure 1 shows a simple sensor monitoring system comprising first 2, second 4 and third 6 sensors connected to a data acquisition device 8 via a data bus 10. The data bus 10 comprises cabling.

Wireless sensor systems in which wireless connections replace standard cables are known. Systems using wireless connections have a number of advantages over traditional cabled systems such as that shown in Figure 1. For example, wireless sensor systems often involve lower costs than traditional cabled systems, in particular they are less expensive to install and maintain. Wireless systems also allow greater flexibility and are easier to use than cabled systems in areas that are difficult or hazardous to cable. Furthermore, wireless connections are not prone to wear or severing. At the same time, consumer awareness and confidence in wireless technology is increasing and the radio devices are becoming cheaper, smaller, more reliable and increasingly standardised.

One example of a wireless system is that described by the Bluetooth™ standard. The Bluetooth™ standard provides a low-cost, low-power radio technology for short-range cable replacement applications. A Bluetooth™ transmitter essentially takes the information traditionally carried by cables and transmits it to a Bluetooth™ receiver. Bluetooth™-enabled devices operate in the unlicensed, 2.4 GHz radio spectrum and use a spread spectrum, frequency-hopping

signal at up to 1600 hops/sec. The signals hop between 79 frequencies at 1 MHz intervals to give a high degree of interference immunity. In a local area, up to seven simultaneous connections can be reliably established and maintained. Thus, Bluetooth™ provides a robust reliable radio link. At present, Class 1 Bluetooth™ transmitters can typically transmit at least 100 metres with a line of sight connection, typically reduced to about 40 metres indoors due to obstructions and reflections.

Wilcoxon Research, Inc. of 21 Firstfield Road, Gaithersburg, MD 20878, USA (www.wilcoxon.com) provide a range of wireless products under the BlueLynx™ name that make use of Bluetooth™ wireless technology to provide a wireless conduit between sensors and data acquisition systems. The BlueLynx™ range of products provides wireless connections between transmitter and receiver pairs.

Figure 2 shows a known wireless sensor system comprising a first sensor 12, a second sensor 14 and a data acquisition device 16. The sensors 12 and 14 are connected to wireless transmitters 18 and 20 respectively. Wireless transmitters 18 and 20 transmit data obtained by sensors 12 and 14 to a wireless receiver 22 that is connected to the data acquisition device 16. By way of example, the wireless transmitters 18 and 20 and the wireless receiver 22 may be Bluetooth™ devices.

The system of Figure 2 is a one-way system in which data passes from the sensor(s) to the data acquisition device. The wireless connection is simply a conduit through which that data flows. The system described with reference to Figure 2 does not allow the receiver to have any control over the sensors. For example, although the sensors can be

configured manually using jumpers, it is not possible using the system of Figure 2 to remotely configure the sensors.

In any particular application of the system of Figure 2, the sensors must be programmed prior to being placed in the field. This may be a specialist task. Any re-programming may not only be a specialist task, but would also require a visit to the site at which the sensor is located. If the sensor is difficult to access, for example if it is positioned in a hazardous environment, this may not be possible, or may at best be expensive.

In the system of Figure 2, the data acquisition device 16 must have information that allows it to identify the type of sensor being used, including the unit of measurement and how to calibrate the transmitted value (typically from volts or milliamps). This information must be provided by an operator. Thus a skilled operator is required in order to make use of any sensor in the system of Figure 2. The requirement for a skilled operator not only increases the cost of configuring such a system, but is also a potential source of error in the system.

It is an object of the present invention to address at least some of the above-mentioned problems.

The present invention provides a data receiving unit, wherein, in use, said data receiving unit is arranged to receive data relating to one or more sensors from one or more transmission modules over a link that includes a wireless connection, wherein each transmission module stores configuration data for the sensor(s) connected to that transmission module; said data receiving unit obtains at least some of said configuration data via said wireless

connection; and said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor. The data receiving unit may be arranged to modify said configuration data by sending instructions to said transmission module via said wireless link.

The present invention also provides a data receiving unit, wherein, in use, said data receiving unit is arranged to receive data relating to one or more sensors from one or more transmission modules over a link that includes a wireless connection, wherein each transmission module stores configuration data for the sensor(s) connected to that transmission module; said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link; and said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor.

The present invention also provides a transmission module coupled to one or more sensors, wherein, in use, said transmission module transmits data from said sensor(s) to a data receiving unit over a link that includes a wireless connection, wherein said transmission module stores configuration data for said sensor(s); said data receiving unit obtains at least some of said configuration data via said wireless connection; and said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor. The said data receiving unit may be arranged to modify said configuration data by sending instructions to said transmission module via said wireless link.

The present invention further provides a transmission module coupled to one or more sensors, wherein said transmission

module transmits data from said sensors to a data receiving unit over a link that includes a wireless connection, wherein said transmission module stores configuration data for said sensors; said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link; and said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor.

The present invention further provides a method of configuring a sensor monitoring system, the system comprising one or more transmission modules, a data receiving unit and one or more sensors, each sensor coupled to one of said transmission modules, wherein each transmission module stores configuration data for the sensors coupled to that transmission module, the method comprising the steps of: transmitting data relating to said one or more sensors from said transmission module(s) to said data receiving unit over a link that includes a wireless connection; arranging for said data receiving unit to obtain at least some of said configuration data via said wireless connection; and arranging for said data receiving unit to interpret data received from a sensor on the basis of the configuration data for said sensor. Further, the said data receiving unit may be arranged to modify said configuration data by sending instructions to said transmission module via said wireless connection.

The present invention further provides a method of configuring a sensor monitoring system, the system comprising one or more transmission modules, a data receiving unit and one or more sensors, each sensor coupled to one of said transmission modules, the method comprising the steps of: arranging for each of said transmission modules to store

configuration data relating to the sensors connected thereto; arranging for said data receiving unit to modify said configuration data by sending instructions to said transmission module via said wireless connection; and arranging for said data receiving unit to interpret data received from a sensor on the basis of the configuration data for said sensor.

The present invention also provides a computer program product which, in use, is arranged to receive data from one or more sensors from a transmission module over a link that includes a wireless connection, wherein the computer program product interprets data received from a sensor on the basis of configuration data for that sensor stored at said transmission module, wherein said computer program product obtains at least some of said configuration data from said transmission module via said wireless link.

The present invention further provides a computer program product which, in use, is arranged to receive data from one or more sensors from a transmission module over a link that includes a wireless connection, wherein the computer program product interprets data received from a sensor on the basis of configuration data for that sensor stored at said transmission module, wherein said computer program product is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link.

The present invention yet further provides a computer program product, which, in use, is arranged to transmit data from one or more sensors to a data receiving unit over a link that includes a wireless connection and to transmit configuration data relating to said one or more sensors to said data

receiving unit over said link so that said data receiving unit can interpret said data.

The present invention also provides a computer program product, which, in use, is arranged to transmit data from one or more sensors to a data receiving unit over a link that includes a wireless connection, wherein said computer program product modifies said configuration data in accordance with instructions received from said data receiving unit.

The present invention addresses the problems associated with the prior art systems noted above in which a one-way sensor system is provided wherein data passes from a sensor to a data acquisition device via a wireless connection that acts as a conduit by giving an operator a certain degree of control over the sensors.

In accordance with one form of the invention, the data receiving unit includes a display for plotting data relating to one or more of said sensors received from one or more of said one or more transmission modules. That display may be arranged to plot data as it is received from said transmission module(s). The display enables an operator at the data receiving unit to monitor the outputs of the sensors. The display may be arranged to be plotted without operator intervention by providing the display with application software that is able to interpret the incoming data on the basis of the configuration data known to the application software.

A data logger may be provided for logging data received from said transmission module relating to one or more of said sensors. Furthermore, a display may be provided for plotting data logged by said data logger. In addition to data

received from the sensors themselves, other information, such as errors and configuration information may be stored in the data logger.

Each transmission module may have a user-configurable power setting. Those power settings may be arranged to be set at said data receiving unit. This feature is useful as it enables an operator at the data receiving unit to remotely configure the power setting of each transmission module.

The power settings may include a request mode, wherein a transmission module operating in a request mode takes readings in response to instructions, for example, from the data receiving unit. Alternatively, or in addition, the user-configurable power settings may include a periodic mode, wherein a transmission module operating in a periodic mode takes readings on a periodic basis. Other power settings may be provided, such as taking readings on a periodic basis, but transmitting said data only in response to an instruction to do so.

Each sensor and/or transmission module may be associated with a user-configurable reading period defining the time between consecutive readings made by the transmission module. Each transmission module may be associated with a user-configurable transmit period defining the time between consecutive transmissions of data to said data receiving unit. In one form of the invention, the reading period is shorter than the transmit period. In another form of the invention, the reading and transmit periods are equal.

In one form of the invention, each sensor may be switched off unless it is reading or transmitting data, or preparing to read or transmit data. For example, a sensor in a periodic

mode may be off until the transmission module to which it is connected determines that it is time to take a reading and a sensor in a request mode may be off until the transmission module to which it is connected is instructed to take a reading. Further, a transmission module may have a low power mode in which all non-essential elements of the transmission module are turned off to conserve power. For example, in a periodic mode, all elements of the transmission module may be turned off with the exception of the timing circuit of the microcontroller. In a request mode, the timing circuit of the microcontroller may be turned off.

A sensor may be associated with one or more user-configurable alarm conditions. In one form of the invention, data is arranged to be transmitted to said data receiving unit immediately on detection of a breach of one of said alarm conditions. The transmission module may be in a low power, sleep mode until such an alarm condition occurs. By providing such alarm conditions, a balance can be struck between the desire to reduce the number of power-consuming transmissions of data between a transmission module and a data receiving unit and the desire to ensure that unusual data that may indicate a problem with a device being monitored is transmitted to the data receiving unit without delay.

The data receiving unit may comprise a Bluetooth™ transceiver. The transmission module may comprise a Bluetooth™ transceiver. There are a number of advantages of using Bluetooth™ transceivers as discussed above. Other wireless connections can also be used. The present invention also provides a system comprising a data receiving unit as described above and a transmission module as described above, for example a system in accordance with the present invention

may comprise a data receiving unit comprising a Bluetooth™ transceiver that is in communication with a transmission module comprising a Bluetooth™ transceiver.

By way of example only, embodiments of the present invention will now be described with reference to the accompanying drawings, of which:

Figure 1 shows an exemplary sensor system that is well known in the art;
Figure 2 shows a known wireless sensor transmission system;
Figure 3 shows an overview of a wireless sensor monitoring system in accordance with the present invention;
Figure 4 is a simplified block diagram of a transmission module used in the present invention;
Figure 5 is a graph showing the power consumption over time of an exemplary sensor operating in a Periodic Mode in accordance with an embodiment of the present invention; and
Figure 6 shows an exemplary use of a sensor monitoring system in accordance with the present invention.

Figure 3 shows a wireless sensor monitoring system indicated generally by the reference numeral 24 in accordance with an embodiment of the present invention. The system 24 comprises a first transmission module 26, to which first 28, second 30 and third 32 sensors are connected and a second transmission module 34, to which a fourth sensor 36 is connected. First and second transmission modules 26 and 34 comprise transmitters that transmit data obtained from sensors 28, 30, 32 and 36 to a receiver 38. Receiver 38 passes data to a data acquisition device 40 over bus 42.

In the use of the system 24, data sampled by transmission modules 26 and 34 from the various sensors are transmitted to

the receiver 38 from where the data are passed to the data acquisition device 40. In addition, control information can be sent from the data acquisition device 40 to the transmission modules 26 and 34. This control information may include data relating to sensor configuration, such as control information relating to power management and signal calibration.

Figure 4 shows a simplified block diagram of the transmission module 26 connected to sensors 28, 30 and 32. The transmission module 26 comprises a microcontroller 44, power unit 46, DC-to-DC converter 48, oscillator unit 50, transceiver 52 and antenna 54. The transmission module 26 includes four sensor connections for connecting to the sensors 28, 30 and 32 (one sensor connection is unused in the example of Figure 4).

The microcontroller 44 samples signals received from sensors 28, 30 and 32. The microcontroller 44 receives power from a power module 46. The power module 46 also powers the oscillator unit 50 and the transceiver 52 under the control of the microcontroller 44. In one form of the invention, the power module 46 receives mains power: in another form of the invention, the power module 46 receives power from batteries housed in the transmission module. In any case, a DC-to-DC converter 48 is provided to convert, under the control of the microcontroller 44, the voltage output of the power module 46 to a 24V supply used to power the sensors connected to the transmission module 26. Oscillator unit 50 provides a clock signal for the microcontroller.

Data for transmission to the receiver 38 is sent from the microcontroller 44 to transceiver 52. Communications between the microcontroller 44 and the transceiver 52 make use of a

universal asynchronous receiver/transmitter (UART) interface. The output of the transceiver 52 is coupled to the antenna 54. In a similar way, data received by the transmission module 26 is sent to the transceiver 52 via the antenna 54 and passed from the transceiver 52 to the microcontroller 44 under the control of the UART interface.

As described above, the transmission module 26 is connectable to up to four sensors and provides the 24V power input required by the sensors. The sensors provide a 4-20mA data signal to the transmission module 26 and have 0 to 5V and 0 to 10V options that are manually selectable.

In one form of the invention, data relating to the calibration of a sensor connected to the transmission module 26, as well as any other configuration settings, such as sample frequency, must be entered manually by an operator. Once entered, this information is stored within the memory of the microcontroller 44. In another form of the invention, a pre-programmed transmission module is provided together with sensors for which the transmission module has been programmed, so that the sensor settings do not need to be entered manually by an operator.

When a new transmission module 26 is added to the system of Figure 3, receiver 38 obtains the configuration data for the sensors connected to that transmission module 26 as stored by the microcontroller 44 of the transmission module 26. This configuration data is passed to the data acquisition device 40. Thus, any data sampled by the microcontroller 44 and sent to the data acquisition device 40 can be interpreted by the data acquisition device without user intervention. Removing the need for user intervention eliminates the

possibility of human error in the configuration of the system.

When a new transmission module is added to a sensor monitoring network, an initialisation process takes place. First, the transmission module must connect to a receiver. In one form of the invention, a transmission module stores identification data for a receiver with which it is intended to communicate, but this is not essential. Once the transmission module is in communication with a receiver, the stored settings of that transmission module (i.e. the details of the sensors connected to that module) are sent to the receiver. The transmission module then waits for instructions from the receiver. This may be in the form of instructing the transmission module to function with the current settings, or in the form of amendments to the default settings (e.g. an instruction to operate in a different power mode).

The transmission module is able to communicate with any receiver. For example, a particular transmission module may expect to communicate with a particular receiver unit, but if that receiver unit is unavailable, the transmission module has the capability to find and communicate with a different receiver. Thus, in a system having a number of receivers, a problem with one receiver may not result in the monitoring system associated with that receiver failing completely. Alternatively, a transmission module may not have a preferred receiver, in which case the transmission module simply communicates with the first receiver it makes contact with. Furthermore, a transmission module may be moved from one wireless network to another (at a different plant, for example) without an operator being required to reconfigure either system. Again, the absence of the need for an

operator to reconfigure the system makes the system cheaper and easier to use and reduces the possibility of human error in the setup of the system.

In addition to obtaining the default configuration details of a new sensor added to the system, the receiver 38 can be used to send user-defined configuration details to the transmission module 26 via the wireless link. There are a number of configuration settings that can be controlled from the data acquisition device 40. They include: sensor names, operating modes, readings periods, transmission periods, calibration parameters and data thresholds. Details of those settings are described below.

Sensors can be named by an operator at the data acquisition device. Clearly, this is useful for identification purposes.

A particular transmission module may have a number of operating modes, including a default mode which will be used in the absence of instructions to the contrary. By way of example, a transmission module may be able to operate in either a Request Mode or a Periodic Mode, both of which can be considered power saving modes.

Figure 5 is a simplified representation of the power consumption of an exemplary sensor and transmission module operating in a Periodic Mode. When operating in a Periodic Mode, a transmission module takes sensor readings (or samples) at regular intervals, such as at times R_0, R_1, R_2 and R_3. The data relating to those readings is stored in the memory of the microcontroller 44 of the transmission module 26. The time between two consecutive sensor readings taken by the transmission module is called the Readings Period. Thus the period between readings R_1 and R_2, for example, is

the Readings Period. The sensor data stored at the transmission module is sent to the relevant receiver at regular intervals, such as at times T_0, T_1 and T_2. The time between two consecutive transmissions is called the Transmission Period.

In the example of Figure 5, a number of samples are taken before a transmission to the receiver occurs (i.e. the Readings Period is shorter than the Transmission Period). This is an example of Periodic Mode providing multiple samples per transmission. In an alternative form of the Periodic Mode, one sample is taken per transmission (i.e. the Readings Period is the same length as the Transmission Period).

Figure 5 shows the power consumption of such a transmission module operating in a Periodic Mode providing multiple samples per transmission. When the sensor is not taking a reading and the transmission module is not transmitting data, the transmission module is in a low power, sleep mode in which the sensors are turned off. The only activity that the transmission module is required to perform is the monitoring of time, so that the expiry of the reading and transmission periods can be determined. Shortly before a reading is to be taken, the sensor is activated and prepares to take the reading. Similarly, shortly before a data transmission is to occur, the transceiver 52 is activated and prepares to transmit data.

In one form of the invention, sensors are turned on 1.5 seconds before a reading is taken. In a similar way, transceiver 52 is turned on shortly before a transmission of data takes place. This can be seen in Figure 5, wherein the

power consumption is generally very low, but increases just before a reading is taken, or a transmission of data occurs.

In a Request Mode, a transmission module 26 sends data in response to a Request from the receiver 38. Thus, a transmission module in a Request Mode is generally in a low power mode in which it takes no action other than monitoring an input to the transmission module from the receiver 38. When the receiver requests a reading to be taken, the transmission module provides power to the sensors and takes a reading from the sensors. The transceiver 52 then sends data relating to those readings to the receiver 38 before the transmission module returns to the low power mode.

In some forms of the invention, when the transmission module is in a low power mode, all non-essential parts of the transmission module are switched off to save power. For example, in a Periodic Mode, all elements of the transmission module can be turned off with the exception of those elements associated with the timing circuit of the microcontroller. In particular, the transceiver 52, which is generally a high power device, can be switched off. In a Request Mode, the transceiver cannot be switched off but other elements, such as the timing circuits, can be switched off.

A timestamp may be added to the data so that the time with which the data sample is associated can be determined at a later date.

When data is transmitted to the receiver, the transmission module waits to receive an acknowledgement that it has been received. If an acknowledgement is not received, this is recorded in an error log at the transmission module. The data may be resent, either at that time, or at the next time

data is transmitted (e.g. in response to a receiver request, or at the expiry of a transmission period).

The calibration parameters referred to above may include the range of a sensor signal (e.g. 4-20 mA, 0-5V, 0-10V), the sensor units (e.g. degrees Centigrade) and the valid range of the sensor (e.g. -25 to +50 degrees Centigrade). Thus the present invention works with standard sensors: there is no requirement for sensors to be designed specifically for the system of the present invention.

Data Thresholds may be set defining significant thresholds and the action that should occur if those thresholds are exceeded. Consider the following example in which a transmission module is connected to a temperature sensor and is set to take a temperature reading on an hourly basis and to send the acquired data to the receiver 38 at midnight every day, including details of all the temperature measurements taken. This is similar to the situation shown in Figure 5, where a number of readings are taken on a periodic basis, and the readings are sent by the transmission module to a receiver on a periodic basis. In addition to the transmission of data to the receiver at the expiry of a transmission period, the transmission module 26 may be instructed to inform the data acquisition unit immediately on detection of a temperature outside a user-defined range, i.e. whenever the detecting temperature is above or below user-defined thresholds.

Thus, a transmission module may be configured so that, under normal operating conditions, the measured data are transmitted to the receiver on a daily basis, but as soon as a reading is taken that is outside the normal range, that data is transmitted immediately to the receiver. This

arrangement has the advantage of a relatively small number of power consuming transmissions being required during normal operation together with the advantage of immediate notification whenever an unusual reading that may indicate the presence of a problem is taken.

In a variant of the Request Mode, termed a Request With Alarms Mode, the transmission module takes readings on a periodic basis, as described above with respect to the Periodic Mode, but only transmits data to the receiver on request, or when an alarm condition occurs.

The data acquisition unit 40 includes a user interface to enable an operator to view data and to interact with the monitoring system. The user interface is controlled by application software and comprises a live viewer mode, a logger mode, an historical viewer mode and alarms and error management modes, as described below. An operator can switch between the various modes. In the form of the invention shown in Figure 3, the data acquisition unit 40 obtains data from the receiver 38 via a network connection. This is not essential. Indeed, it is possible for the data acquisition unit 40 and the receiver 38 to be part of the same computer. In one form of the invention, the receiver 38 is connected to the data acquisition device 40 via either RS-232, Ethernet or USB (in the case of a USB connection, the data acquisition device also powers the receiver) and the data acquisition device 40 is a PC running software to control the receiver 38. In an alternative form of the invention, the data acquisition device and its associated software are incorporated in the receiver 38. A separate PC may then be provided in order to provide a user interface and to include data plotting and data logging software. Communications

between such a combined receiver/controller and PC may be by TCP/IP.

In the live viewer mode, the application software receives and interprets data received from the receiver 38 and plots this data on a chart. Data may be plotted for each sensor to which the system is connected, or the operator may select the sensors for which data should be displayed.

The application software is able to interpret the data received from the sensors via the receiver 38 from the configuration data known to the application software (that configuration data having previously been obtained from the transmission module). Moreover, when a new sensor is added to the system, the data acquisition unit is able to obtain the configuration data of that new sensor from the transmission module, thereby enabling the application software to interpret the data from that sensor and to plot the data received from the new sensor with the appropriate scale and units. Accordingly, the live viewer mode does not generally require operator intervention.

In the logger mode, the application software interprets information received from the receiver 38 and stores that information in log files. The information stored can include data from the sensors, details of sensors added to the system, alarms and errors. Separate files may be provided for storing the various forms of information (e.g. readings by the sensors and error logs may be stored separately). Furthermore, data from individual sensors, or particular groups of sensors, may be stored separately. Log files may be automatically deleted after a predetermined period of time.

The historical viewer can be used to plot information stored in the log files. Viewers can also be provided to view alarms and errors stored by the logger. In one form of the invention, the historical viewer includes a search function to retrieve data that matches selected features and includes common tools such as zoom, autoscale and cursors.

Figure 6 shows a bearing monitor, indicated generally by the reference numeral 56 including features of the present invention. The bearing monitor 56 comprises a bearing 58, a speed sensor 60, accelerometer 62 and temperature sensor 64 monitoring the bearing 58 and a transmission module 66 to which the sensors 60, 62 and 64 are connected.

The transmission module 66 of the bearing monitor 56 may operate in a Periodic Mode, as described above, in which the transmission module 66 takes readings on a periodic basis, and reports to a receiver on a periodic basis. Further, the temperature sensor 64, for example, may be provided with an alarm condition, which is triggered if the temperature rises above a predetermined level. The system may be programmed to warn an operator immediately on detection of such a condition.

Alternatively, the system of Figure 6 may operate in a Request Mode so that data from the sensors is only transmitted back to the data acquisition unit on request from that unit. For example, the transmission module may be instructed to take measurements whilst the bearing 58 is used. In this way, when the bearing 58 is not in use, the sensors are not powered and the transmission module is in a low power mode, thereby reducing the overall power consumption, but when the bearing is in use, readings are taken so that any potential problems can be monitored.

The sensors 60, 62 and 64 are used to monitor the performance of the bearing 58 and to report back to a central data acquisition device. In this way, any defect leading to unexpected behaviour can be detected at an early stage and the bearing replaced, hopefully before any serious damage is caused. By providing a large number of sensors on a range of different elements of a complex piece of machinery, an integrated monitoring system can be provided to monitor the machine. This can clearly be used to improve the reliability of such a machine.

In one form of the invention, the microcontroller 44 is a PIC18LF6720 microcontroller having 128K flash memory, 3K embedded RAM and an embedded analogue-to-digital converter (ADC). The receiver module used can be connected to any number of transmission modules, each of which can be connected to 4 sensors. Each transmission module can read up to 8000 samples per second per channel.

The wireless monitoring system can be connected to any number of sensors. The modular approach enables the system to be used in a wide variety of applications. The automatic configuration and detection of sensors means that less time is required for the initial set-up of the system and for the addition of new sensors to the system. Moreover, new sensors can be added by any competent electrician since no specialist skills are required. The automatic set-up also reduces the possibility of human error.

The system described above can make use of the Bluetooth™ standard, but other radio technologies could be used, such as frequency modulation (FM), the Zigbee standard and other proprietary systems. Further, although two possible power

saving modes are described, the present invention is not limited to use with those power saving modes and any other power saving modes could be used.

Claims:

1. A data receiving unit, wherein, in use, said data receiving unit is arranged to receive data relating to one or more sensors from one or more transmission modules over a link that includes a wireless connection, wherein:

each transmission module stores configuration data for the sensor(s) connected to that transmission module;

said data receiving unit obtains at least some of said configuration data via said wireless connection; and

said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor.

2. A data receiving unit as claimed in claim 1, wherein said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link.

3. A data receiving unit, wherein, in use, said data receiving unit is arranged to receive data relating to one or more sensors from one or more transmission modules over a link that includes a wireless connection, wherein:

each transmission module stores configuration data for the sensor(s) connected to that transmission module;

said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link; and

said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor.

4. A data receiving unit as claimed in any preceding claim, further comprising a display for plotting data relating to

one or more of said sensors received from one or more of said one or more transmission modules.

5. A data receiving unit as claimed in claim 4, wherein said display is arranged to plot data as it is received from said transmission module(s).

6. A data receiving unit as claimed in any preceding claim, further comprising a data logger for logging data received from said transmission module(s) relating to one or more of said sensors.

7. A data receiving unit as claimed in claim 6, further comprising a display for plotting data logged by said data logger.

8. A data receiving unit as claimed in any preceding claim, wherein each transmission module has a user-configurable power setting.

9. A data receiving unit as claimed in claim 8, wherein said power settings are arranged to be set at said data receiving unit.

10. A data receiving unit as claimed in claim 8 or claim 9, wherein said user-configurable power settings include a request mode, wherein a transmission module operating in a request mode takes readings from the sensor(s) attached to that transmission module in response to instructions.

11. A data receiving unit as claimed in any one of claims 8 to 10, wherein said user-configurable power settings include a periodic mode, wherein a transmission module operating in a periodic mode takes readings from the sensor(s) attached to

that transmission module on a periodic basis.

12. A data receiving unit as claimed in claim 11, wherein each sensor and/or transmission module is associated with a user-configurable reading period defining the time between consecutive readings made by the transmission module.

13. A data receiving unit as claimed in claim 11 or claim 12, wherein each transmission module is associated with a user-configurable transmit period defining the time between consecutive transmission of data to said data receiving unit.

14. A data receiving unit as claimed in any preceding claim, wherein one or more sensors have one or more user-configurable alarm conditions associated therewith.

15. A data receiving unit as claimed in claim 14, wherein data is arranged to be transmitted to said data receiving unit immediately on detection of a breach of one of said alarm conditions.

16. A data receiving unit as claimed in any preceding claim, comprising a Bluetooth™ transceiver.

17. A transmission module arranged to be coupled to one or more sensors, wherein, in use, said transmission module transmits data from said sensor(s) to a data receiving unit over a link that includes a wireless connection, wherein:

said transmission module stores configuration data for said sensor(s);

said data receiving unit obtains at least some of said configuration data via said wireless connection; and

said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor.

18. A transmission module as claimed in claim 17, wherein said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link.

19. A transmission module coupled to one or more sensors, wherein said transmission module transmits data from said sensors to a data receiving unit over a link that includes a wireless connection, wherein:

said transmission module stores configuration data for said sensors;

said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link; and

said data receiving unit interprets data received from a sensor on the basis of the configuration data for said sensor.

20. A transmission module as claimed in any one of claims 17 to 19, wherein said transmission module is associated with a user-configurable power setting.

21. A transmission module as claimed in claim 20, wherein said power setting is set at said data receiving unit.

22. A transmission module as claimed in claim 20 or claim 21, wherein said power setting includes a request mode in which the transmission module takes readings in response to instructions.

23. A transmission module as claimed in any one of claims 20 to 22, wherein said power setting includes a periodic mode in which the transmission module takes readings on a periodic basis.

24. A transmission module as claimed in claim 23, wherein said transmission module is associated with a user-configurable reading period defining the time between consecutive readings made by the transmission module.

25. A transmission module as claimed in claim 23 or claim 24, wherein the transmission module is associated with a user-configurable transmit period defining the time between consecutive transmissions of data to said data receiving unit.

26. A transmission module as claimed in any one of claims 17 to 25, wherein each sensor is powered only when it is taking, or preparing to take, a reading, or transmitting, or preparing to transmit, data.

27. A transmission module as claimed in any one of claims 17 to 26, wherein one or more of said sensors have one or more user-configurable alarm conditions associated therewith.

28. A transmission module as claimed in claim 27, wherein data is transmitted to said receiver immediately on detection of a breach of one of said alarm conditions.

29. A transmission module as claimed in any one of claims 17 to 28, comprising a Bluetooth™ transceiver.

30. A transmission module as claimed in any one of claims 17 to 29, further comprising the said one or more sensors.

31. A system comprising a data receiving unit as claimed in any one of claims 1 to 16 and a transmission module as claimed in any one of claims 17 to 30.

32. A method of configuring a sensor monitoring system, the system comprising one or more transmission modules, a data receiving unit and one or more sensors, each coupled to one of said transmission modules, wherein each transmission module stores configuration data for the sensors coupled to that transmission module, the method comprising the steps of:

transmitting data relating to said one or more sensors from said transmission module(s) to said data receiving unit over a link that includes a wireless connection;

arranging for said data receiving unit to obtain at least some of said configuration data via said wireless connection; and

arranging for said data receiving unit to interpret data received from a sensor on the basis of the configuration data for said sensor.

33. A method as claimed in claim 32, wherein said data receiving unit is arranged to modify said configuration data by sending instructions to said transmission module via said wireless connection.

34. A method of configuring a sensor monitoring system, the system comprising one or more transmission modules, a data receiving unit and one or more sensors, each coupled to one of said transmission modules, the method comprising the steps of:

arranging for each of said one or more transmission modules to store configuration data relating to the sensors coupled thereto;

arranging for said data receiving unit to modify said configuration data by sending instructions to said transmission module(s) via said wireless connection; and

arranging for said data receiving unit to interpret data received from a sensor on the basis of the configuration data for said sensor.

35. A computer program product which, in use, is arranged to receive data from one or more sensors from a transmission module over a link that includes a wireless connection, wherein the computer program product interprets data received from a sensor on the basis of configuration data for that sensor stored at said transmission module, wherein said computer program product obtains at least some of said configuration data from said transmission module via said wireless link.

36. A computer program product which, in use, is arranged to receive data from one or more sensors from a transmission module over a link that includes a wireless connection, wherein the computer program product interprets data received from a sensor on the basis of configuration data for that sensor stored at said transmission module, wherein said computer program product is arranged to modify said configuration data by sending instructions to said transmission module via said wireless link.

37. A computer program product, which, in use, is arranged to transmit data from one or more sensors to a data receiving unit over a link that includes a wireless connection and to transmit configuration data relating to said one or more sensors to said data receiving unit over said link so that said data receiving unit can interpret said data.

38. A computer program product, which, in use, is arranged to transmit data from one or more sensors to a data receiving unit over a link that includes a wireless connection, wherein said computer program product modifies said configuration data in accordance with instructions received from said data receiving unit.

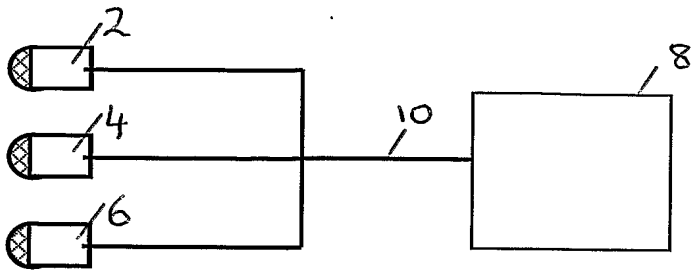

Figure 1

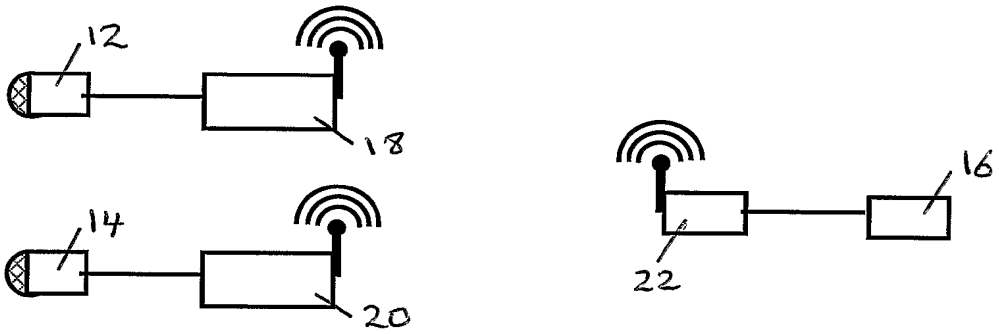

Figure 2

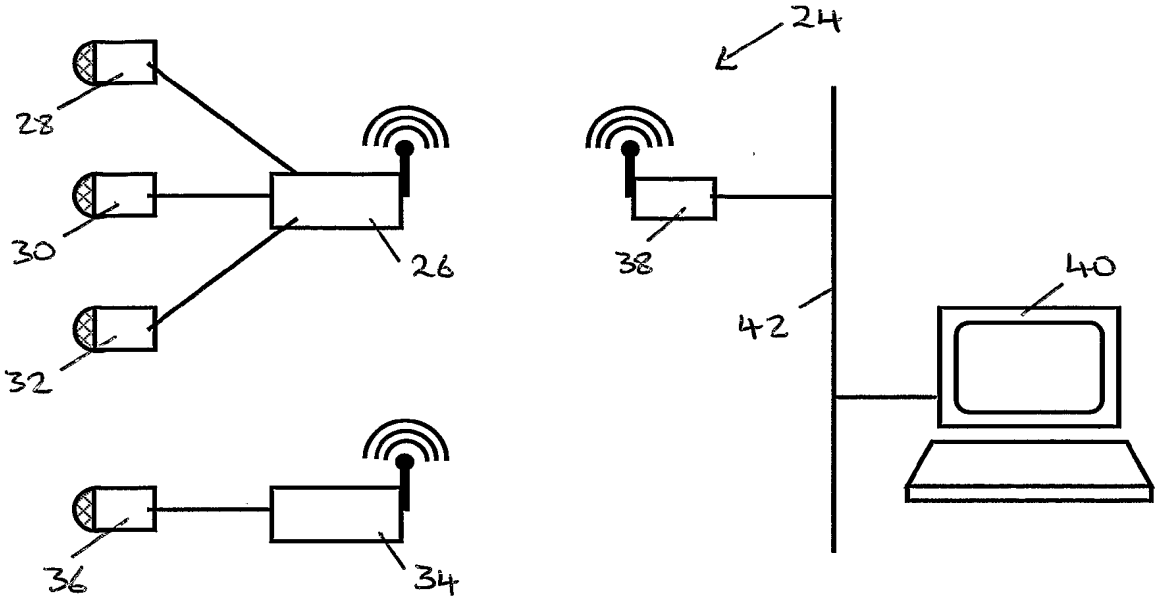

Figure 3

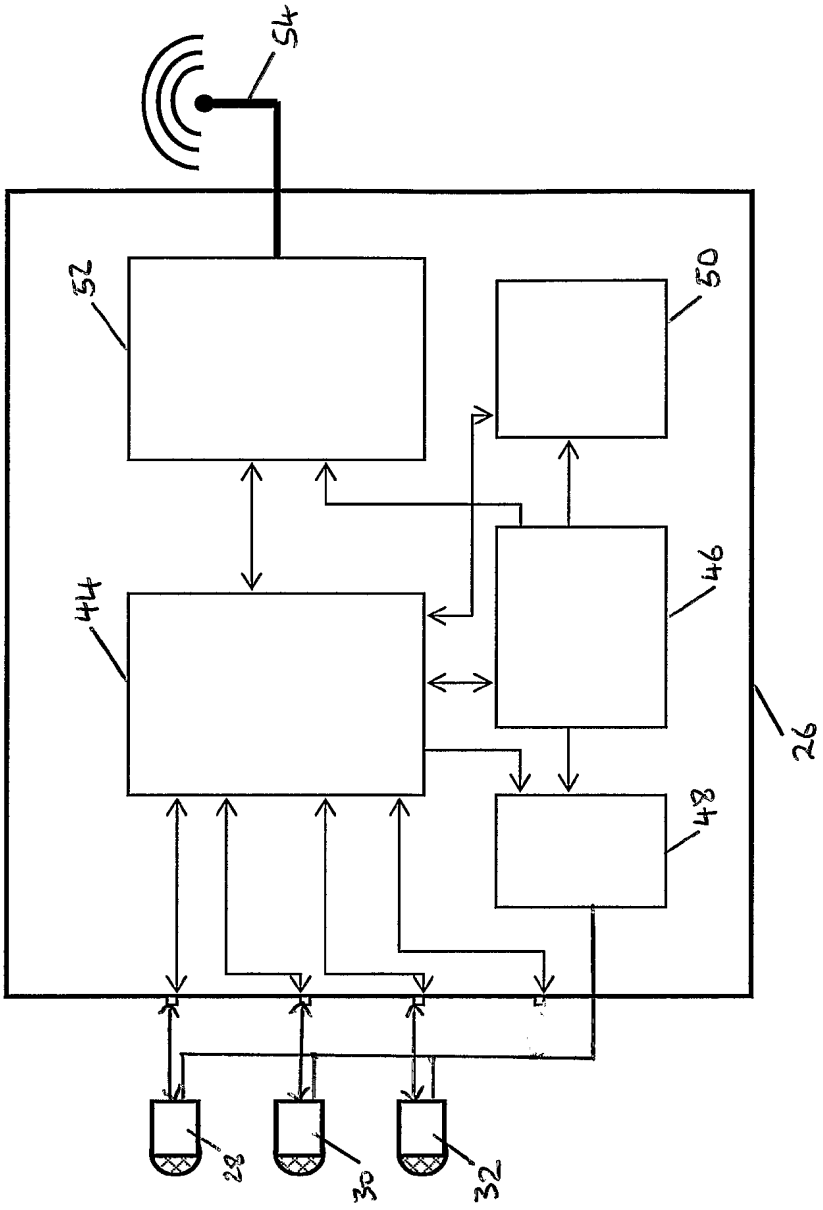

Figure 4

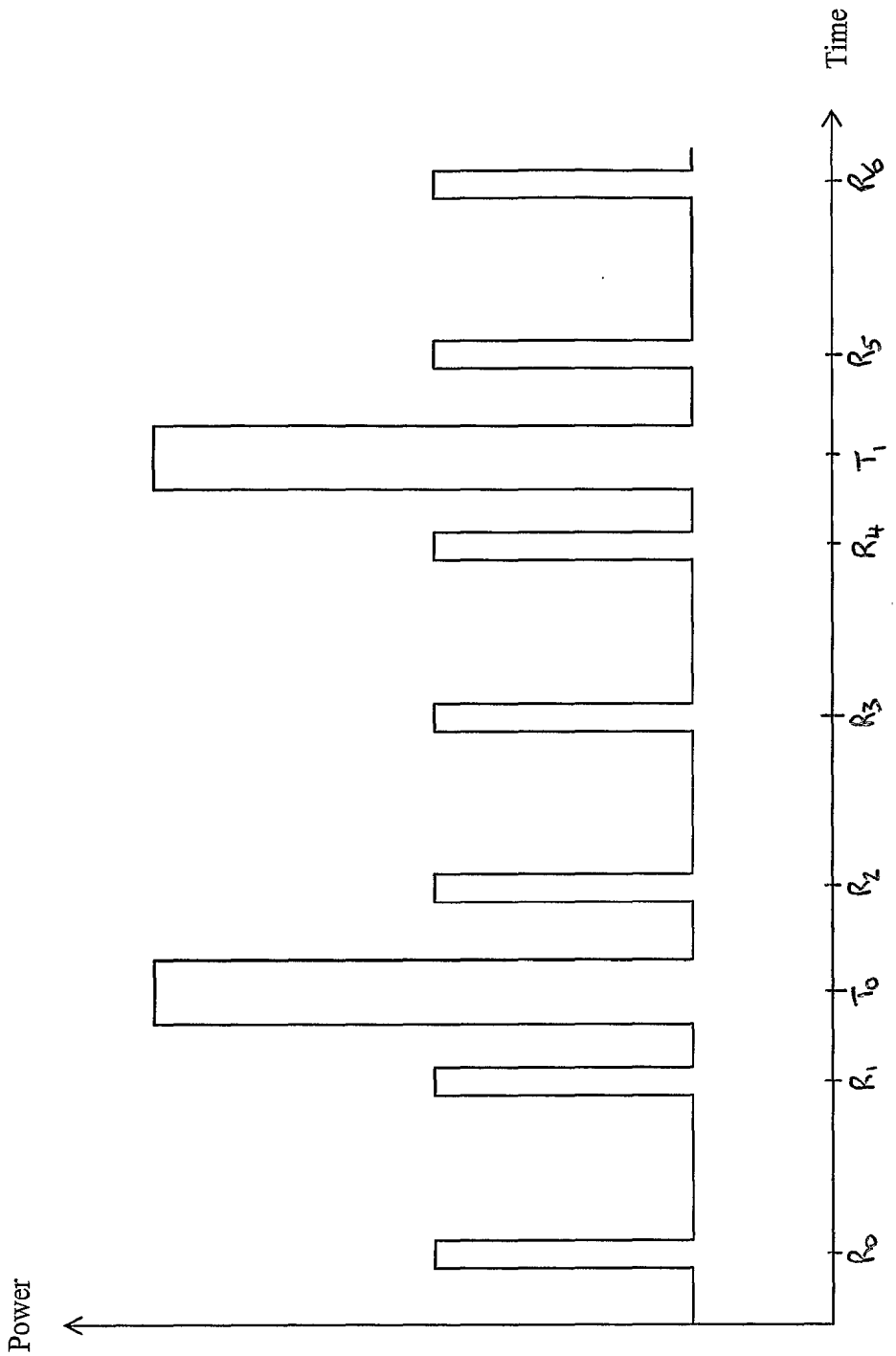

Figure 5

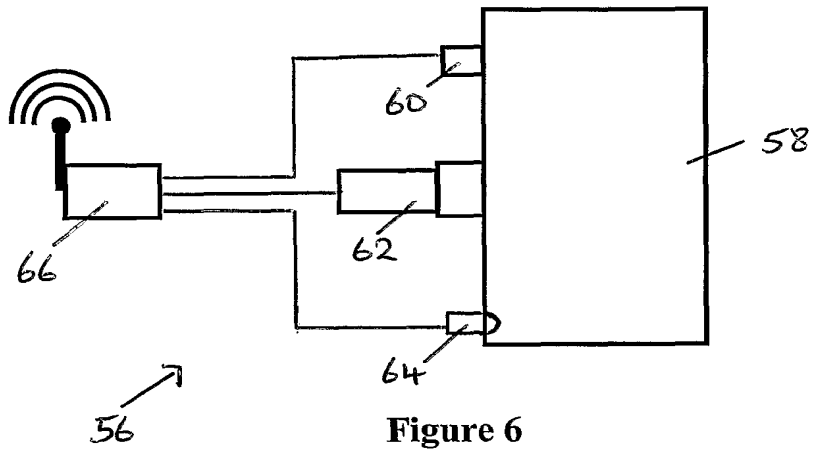

Figure 6